DOCUMENT RESUME

ED 411 833 IR 056 660

AUTHOR Garcia-Sierra, A. J.

TITLE Intelligent Agents: Information Strategies for the Information Society.

PUB DATE 1996-00-00

NOTE 9p.; In: Online Information 96. Proceedings of the International Online Information Meeting (20th, Olympia 2, London, England, United Kingdom, December 3-5, 1996); see IR 056 631.

PUB TYPE Reports - Descriptive (141) -- Speeches/Meeting Papers (150)

EDRS PRICE MF01/PC01 Plus Postage.

DESCRIPTORS *Artificial Intelligence; Computer Literacy; Computer Mediated Communication; Flexible Scheduling; Foreign Countries; Futures (of Society); *Information Industry; Information Technology; Internet; *Technological Advancement; Work Environment

IDENTIFIERS *United Kingdom

ABSTRACT

In the workplace of today which is increasingly being overloaded with information, the concept of intelligent information agents has been widely prescribed. This paper briefly looks at the United Kingdom Government's Information Society Initiative which has been fueled by the realization that information is the key component of the ongoing information revolution. The paper then concentrates on the role of intelligent information agents in providing future generations with a superior course for flexible information working. After describing an enterprise-wide information strategy, the role of the Internet, and intelligent agents, the paper outlines requirements of intelligent information agents, which should be able to: identify other agents with which to communicate; establish a reliable communication channel with other agents; identify and be able to use a protocol for the ensuing dialogue; identify and use a common language to exchange information knowledge; know what terms within the language to use to guarantee that the other agent(s) will interpret the expressions in the same way; and know how to handle inconsistent information and the eventual mismatches that arise from different languages, views, translations and so on around all of the thousands of distributed computers in the world which are hooked up to the Internet. It then looks at the three main processes of a commercial enterprise, namely purchasing, producing and selling. (Contains 21 references.) (Author/AEF)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED 411 833

Intelligent Agents: Information Strategies for the Information Society

By:

A.J. Garcia-Sierra

PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

B.P. Jeapes

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

☐ This document has been reproduced as received from the person or organization originating it.

☐ Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

BEST COPY AVAILABLE

IR056660

Intelligent agents: information strategies for the Information Society

A.J. Garcia-Sierra
BT Electronic Commerce Innovation Centre, Cardiff University of Wales, UK

Abstract: *The ever-increasing requirement for enterprises to communicate more quickly and more efficiently is evident in a time of decreasing trading barriers in national and international arenas. There is an increasing requirement to acquire, exchange and disseminate the increasing mass of information continually reaching our desktops. An information strategy will be the single most important asset of an innovative enterprise within the next 10 years. As identified in the Bangemann Report in 1994, the Information Society will be a revolution which 'adds huge new capacities to human intelligence and ... changes the way we work together ...' (Ref 1).*
The workplace of today is increasingly being overloaded with information. The concept of intelligent information agents has been widely prescribed as a solution to this problematic overload for some time — agents have effectively been labelled as any localised software which does not reside in a mainframe (Ref 2). However, negotiation is a core part of the software functionality and agents must exhibit some form of intelligence (i.e. they can say no to a request and re-route their queries).
Careful design and development of such agents could well form the basis for tackling the Information Revolution.

Keywords: intelligent agents, Internet, information society, flexible information working

1. Introduction

This paper briefly looks at the UK Government's Information Society Initiative which has been fuelled by the realisation that information is the key component of the on-going information revolution. Information superhighways are exemplified as the high-level path to which companies should be aspiring. In order to follow such a path there is a requirement for an enterprise-wide information strategy. The paper then concentrates on the role of intelligent information agents in providing future generations with a superior course for flexible information working.

2. The Information Society Initiative

A need for a nationwide drive to improve the competence of and access to sources of advice and products to help businesses harness information and communications technologies (ICT) has become clear in recent years. The need for suppliers to orient themselves more towards the needs of businesses, particularly small to medium-sized enterprises (SMEs), has also been growing in evidence. In these respects the UK Government launched the Information Society Initiative (ISI) in February this year as a partnership between industry and Government to help British business thrive in the emerging information-based economy. The Initiative is a four-year programme, aimed to conclude in the year 2000 (Ref 3).

At an almost exponential rate we are seeing computing power roughly doubling every year. This means a brand new PC on your desktop is twice as capable as one bought just twelve months ago — this incredible processing power is being made available at cheaper and cheaper prices in real terms. Perhaps the most important facet to note is that this increasing power, not only of computers but also of communication networks, is used primarily to get hold of information we want.

The industries that create and market these products and services, from telecommunications and broadcasting to information technology and publishing, are increasingly converging to form a single electronic information society. The intelligent use of information, or knowledge, is the key to economic and social development.

The ISI has responded to the competitive challenge rapidly emerging — a challenge in which all components of industry need to respond; to adapt to new ways of thinking and working; to invent and innovate with new products and services; to adapt to new structural relationships with suppliers, customers and other trading partners; and to source new customers in flourishing markets.

3. Information superhighways

In December 1993 the European Council requested that a report be prepared for its meeting in June 1994 by a group of prominent persons on the specific measures to be taken into consideration by the Community and the Member States for the infrastructures in the sphere of information. This report subsequently became known, in the light of his Chairmanship of the High-Level Group on the Information Society, as the Bangemann Report (Ref 1).

Although a very generalised document, specific aspects of the report have laid the foundations for the mass utilisation of information in all its various forms for the near- to mid-term future — essentially what we now know as the information superhighways.

4. Information strategy

An enterprise-wide information strategy could quite simply become the single most important facet of a company operating in the next millennium. Whereas we are all fully conversant with the concept and reality of strategies for production and manufacturing, purchasing, sales and marketing, finance, computing and more recently information technology or systems, and so on, are we not quite so clear that universal to all of these is the core requirement of collecting, collating, disseminating and exchanging information? So, why do companies not seem to be doing just this?

The bare requirements for an enterprise-wide information strategy are unambiguous. Information needs to be got to the right places at the right times. Further, decreasing barriers for international trade are becoming evident around the globe on a daily basis. This must be realised by enterprises who truly wish to incorporate innovation into their company — use the information that is available out there!

But what exactly constitutes an information strategy? For decades companies have been organised according to separate, and often disparate, functions. However, organisations must begin to realise that paper-based and machine operating environments are no longer the dominant domain. The influx of desk-top computers in the last 10 years has dramatically changed the way organisations operate. It is clear that the single most important asset of any organisation is information (perhaps it is time to change the old adage 'it's not what you know, it's who' to something like 'it's not what you know, it's who you know, and who they know, and so on'. The key point being that communicating information is vital in this day). Therefore it is unequivocally logical that an information strategy should be at the top of an organisation's agenda, and not Sales & Marketing, nor Distribution, nor Purchasing, nor Quality, nor Manufacturing, *ad infinitum*.

Each of these traditional functions will become part of the information strategy. Such a strategy should allow organisations to focus on what are the most important communications flows internally and externally; who are the key contacts; which are the key channels; what are the best sources; where are the biggest bottle-necks to success; what makes the internal (and external) supply chain flow and so on.

5. Role of the Internet

As a desk-top accessible medium of information transference, the Internet not only offers an extraordinary wealth of information for those searching (sourcing/input) but also for dissemination (output) and additionally as an exchange medium. This continually increasing medium is the single most important factor in developing true information superhighways. In fact according to John Patrick, Vice President of Internet Technology at IBM, the Internet 'is the information superhighway' (Ref 6). The Internet offers an infrastructure on which an information strategy may be adopted and developed. However, a pre-requisite and possibly the killer application of the future Internet is the concept of intelligent information agents — software which is utilised to deliver such strategies efficiently.

As the Internet, and in particular the hyper-linked graphical element known as the World Wide Web (WWW) has grown, so the number of documents on it has naturally increased (Ref 7). Mauldin estimates that the WWW consists of 32 billion bytes (29.9 gigabits) of document data (Ref 8). Even allowing for inaccuracies in the sampling approach and a substantial element of duplication (in 'mirror' sites), there is still a vast amount of data available online. The more successful the WWW, the greater the problem of information and resource discovery.

It is on these thoughts that the remainder of this paper is based: intelligent agents accessed via a simple desk-top interface, just as the Internet is accessed via easy-to-use graphical browsers.

6. Intelligent information agents — overview

> 'The computer language for agents will be completely safe and very flexible. It may even read your mind occasionally' (Ref 9).

The concept of intelligent information agents has been widely prescribed as a solution to the problematic infor-

mation overload for some time — agents have effectively been labelled as any localised software which does not reside in a mainframe (Ref 10).

Techniques in artificial intelligence (AI) in the past have tended to 'use knowledge about the interests and priorities of people to perform routine organisational tasks such as automatically screening, directing, revising and responding to information' (Ref 11). There are essentially two types of approach behind AI which drive agents:

- 'symbolic AI' approach or 'deliberate thinking' paradigm (Ref 11);
- 'nouvelle AI' approach (or behaviour-based AI) or situated agents (Refs 11, 12).

The former approach patterns itself on a mental mode of intelligence — that is symbolic representations of knowledge, usually configured as intelligence residing in the machines as a set of structures. The agent is essentially meant to be governed by logic. This approach is clearly computing resourceful and requires a great deal of prior knowledge.

The latter approach make less assumptions of internal attributes and does not build elaborate knowledge patterns. These agents become engaged dynamically with other agents and as such build their own 'picture' of events — this picture then assists in activating and completing tasks. This implies by its very nature that learning is a prerequisite for these agents. The learning process is achieved through dialogue with other agents, host computers and subsequent recording.

There appears to be growing acceptance, within and outside of intelligent agent theories, of the idea of behaviourally-based agents which literally sit in an environment and learn whilst there, rather than agents which are predefined with intelligent structures but are less able to learn for themselves (Ref 10). In October this year the Intelligent Systems Group of British Telecom's R&D Laboratories, in Martlesham Heath, published a set of papers in the *BT Technology Journal* (Ref 13) in which this concept of behaviourally-based agents was fully endorsed (to be referenced).

It is the inherent levels of intelligence previously discussed that must be incorporated into the careful design and development of such agents. It is the opinion of the author that these agents will form the basis for tackling the Information Revolution — in other words the 'killer application' of the Internet. But what must be remembered is that agents need effectively to be off-the-shelf products which will assist the management of the ever-growing 'software and information mountains' not only for the cash-rich multinationals of this world but also the thousands of SMEs.

Considering the case of companies which cover large geographical areas, and those which last for a number of years, there is clearly the need to develop agents which can cope with collaborative activities so that inappropriate decisions are avoided. In building agents within an infrastructure which actively supports storage, retrieval and delivery of pertinent information to appropriate decision-makers, activities can continue successfully across processes despite turnovers in personnel (Ref 11).

7. The requirements of intelligent information agents

But what exactly are the requirements of intelligent information agents? Generally, agents must be able to:

- identify which other agents to communicate with;
- establish a reliable communication channel with other agents (and back-up if necessary);
- identify and be able to use a protocol for the ensuing dialogue;
- identify and use a common language to exchange information knowledge;
- know what terms within the language to use to guarantee that the other agent(s) will interpret the expressions in the same way (compare this with 'classical electronic data interchange');
- know how to handle inconsistent information and the eventual mismatches that arise from different languages, views, translations and so on around all of the thousands of distributed computers in the world which are hooked up to the Internet.

These requirements begin to proliferate in magnitude of potential issues, and benefits, as an increasing number of agents are involved in information transactions.

The Media Laboratory at the Massachusetts Institute of Technology (MIT) is conducting a number of projects and experiments to develop the evolution of intelligent agents further (Ref 14):

- *Software Agents* project is applying AI techniques to the field of human-computer interaction;
- *Agents that Reduce Information Overload* project is attempting to deal with the problem of information overload. Software agents are being developed that make personalised suggestions to a user for items the user may want to select (news articles, videos, music, television shows, etc.). This project employs two different techniques: content-based filtering (detection of patterns among the items liked or disliked) and collaborative filtering (detection of patterns among different users and making recommendations to people, based on others who have shown similar tastes);
- *Yenta — Matchmaking Agents* project is developing a software agent that finds people who have never met, but share similar interests, and introduces them to each other. Such introductions can form interest groups and coalitions automatically and can be used to locate someone knowledgeable in a particular area;

- *Remembrance Agents* project is addressing the common human fault of bad memories (unlike humans, computers almost never forget the information they store!). This project is creating agents that help augment human memory by logging everything a user does and all the information which passes through the user's hands, thus helping a user remember some information based on the content or the context of the situation;
- *Kasbah: An Agent Marketplace for Buying and Selling Goods* project is helping to realise a fundamental transformation in the way people transact goods — from requiring constant monitoring and effort to a system where a software agent does most of the work on the user's behalf.

Each of these projects has the potential to reform everyday working practices fundamentally by being applied to business applications.

8. Commercial intelligent agent scenario

The following scenario looks at the three main basic 'processes' of a commercial enterprise, namely purchasing, producing and selling.

8.1. Purchasing

As a major function of any organisation, purchasing should ideally be efficient and effective. One service freely available on the Internet today can assist in this area — *URL-minder* sends users an electronic mail message when a specified Internet site changes (i.e. is updated or edited in some way). Although the service is currently somewhat sporadic, and is best suited for tracking special-interest Web sites that change infrequently, it is a clear indication of how buying could be fundamentally altered in the future.

For example, a similar agent could operate freely on the Internet tracking Web sites of known (and newly formed) suppliers of goods and services which a company may wish to purchase. If a supplier decides to offer discounts or some kind of 'deal' then the purchasing agent could alert its user immediately. Intelligent agents could also be sent out on open networks to gather market intelligence, vet potential suppliers, barter on behalf of a company and even negotiate unique contracts.

The aforementioned MIT Kasbah project provides an excellent overview of how a user wanting to buy or sell a good can create an agent, give it some strategic direction and send it off to the agent market place. The Kasbah agents proactively seek out potential buyers or sellers and negotiate with them on their creator's behalf. The agent's goal is to make the 'best deal' possible, subject to a set of user-specified constraints, such as a desired price, a highest (or lowest) acceptable price and a date to sell (or buy) by. These agents need to be intelligent enough to perform well in a complex, dynamic marketplace and a key feature of Kasbah is that it is open to adding new types of agents which use different selling strategies.

8.2. Producing (processing)

Once the pre-contract stage has been passed and contracts formally set up, all with great assistance from agents, there is the opportunity for Intra-agents (that is agents operating exclusively within a company) to monitor production across the various business functions. For example, a manufacturer might have Intra-agents residing within internal networks which follow the flow of information pertaining to a product's development and life-cycle. Information which needs to be passed through the company could be initiated automatically so that effectively users receive up-to-date information that is only relevant to them.

The Yenta — Matchmaking Agents project being run at MIT exemplifies an extremely important development for intelligent agents. The project is an experiment in creating a decentralised, fault-tolerant application that handles potentially sensitive information (such as individuals' electronic mail, personal files or lists of particular interests) in a responsible and privacy-protecting fashion, using cryptographic and other techniques. The eventual goal is ubiquitous deployment across the Internet. It is clear that if these agents are deployed successfully then there is much scope for usage in the internal operations of a company.

Personalised news services, such as Individual's FIRST!, can also be utilised as agents for internal processing of information (the WWW site can be found at *http://www.individual.com*). FIRST! is a daily customised news service 'used by corporations to institutionalise current awareness and to create smarter, more dynamic organisations.' Individual, Inc. claims FIRST! is geared towards any workgroup that needs to stay abreast of the daily industry events affecting their business. These groups include sales, marketing, product management, finance, purchasing, advertising, public relations and competitive analysis, among others. News stories are delivered each morning in full text, via fax or electronic mail, or as an enterprise-wide feed for groupware platforms such as Lotus Notes and the WWW. This kind of agent will clearly be important for the internal dissemination of company information.

8.3. Selling

As for purchasing, intelligent agents could play a vital role in marketing and selling processes. Sales leads could be highlighted to a sales team which tie in with the concept of electronic trading opportunities (ETOs). These opportunities are being encouraged by the United Nations as part of its World Trade Point initiative. Companies throughout the world, and in particular in developing countries, are given the opportunity to lodge products and

goods on offer (and purchasing requirements) via Trade Points, Chambers of Commerce Training Councils and so on, which are then passed over the Internet (and in some cases, closed networks) to participating organisations. The BT Electronic Commerce Innovation Centre has recently taken on the role of ETO Associate which entitles the Centre's personnel to receive ETOs regularly from around the world. However, at present these are received via electronic mail and are somewhat 'user-unfriendly' — but intelligent agents will have the opportunity to filter linked organisations and potential sales leads.

9. The future — flexible information working

The concept of flexible information working has been dawning in recent years. However, it remains widely misunderstood by many in the commercial domain. The author's personal understanding and vision of the future lies in utilising information in order to work in an optimally efficient and effective manner, giving the individual (and organisation) far more flexibility in when one actually has to work. This may appear revolutionary to some managers: after all, flexi-hours essentially do not exist outside central and local government offices!

However, intelligent information agents offer the opportunity to transact information flows in a timely manner — that is not to say necessarily accelerated but also decelerated where applicable. As communications across the information superhighway become increasingly efficient there will be less and less need for office-based work to continue. The future of mobile, or flexible, working is evident. An increasing number of organisations are providing employees with not only pagers but mobile phones; not only desktop PCs but laptops; not only paper diaries but palmtop electronic organisers and personal digital assistants.

In his book on the technological future, Negroponte discusses how information is relayed and perceived amongst humans and how computers will have to be developed to operate in a similar fashion (Ref 15). Take the example of a translator of languages: it is often a combination of both lingual and bodily expressions that enhances translation, not just a straight-forward word-for-word representation.

Negroponte goes on to use the well-trained English butler as his best metaphor for a 'human-computer interface'. This agent 'answers the phone, recognises the callers, disturbs you when appropriate, and may even tell a white lie on your behalf!' In addition the ideal butler will be 'well trained in timing, versed in finding the opportune moments and respectful of idiosyncrasies'. The key element here is the aforementioned concept of agents possessing knowledge both about something (a process, a field of interest, a way of doing) and about you in relation to that something (your taste, your inclinations, your acquaintances).

The concept of agents which filter news stories and press releases and book holidays or insurance has already become reality. Another application of agents is in scheduling meetings — for those who have used Lotus Notes or MS Mail and so on, you will appreciate that electronically booking dates and times is far easier to handle with the added functionality of electronic mail. But when an agent (the electronic secretary) can do this on a user's behalf the proverbial nut truly shall be cracked. Furthermore agents can take intelligent steps in scheduling meetings over a period of time to ensure one's diary is not too cramped in the near future. This combination of straightforward knowledge utilisation and logical application is the key to the future of intelligent information agents.

The position of information 'handlers' also needs to be addressed: that is, individuals whose job role is primarily information-based (librarians and information-brokers are perhaps the best examples). As recognised by Hermans, human information searchers usually seek help from information intermediaries such as a librarian (Ref 16). Hermans goes on to state that information workers based in larger companies, or those who require information in a more urgent manner, are likely to use information brokers: 'the Internet offers new opportunities for such intermediary/brokering services. Both human as well as electronic brokers are especially valuable when the number of participants is enormous or when information products are exchanged. Electronic brokers can offer two further opportunities over human ones. Firstly, many brokering services require information processing; electronic versions of these services can offer more sophisticated features at a lower cost than is possible with human labour. Secondly, for delicate negotiations a computer mediator may be more predictable, and hence more trustworthy, than a human one.' The latter argument is clearly one likely to cause debate! However, there is certainly a serious point behind unbiased computers, although their flexibility will of course never match a human's.

10. Conclusion

From governmental developments such as the Information Society Initiative to private sector implementations of information-based strategies, we are seeing the advent of an Information Revolution. The Internet will certainly take its place as the medium of the future for the realisation of true information superhighways. Intelligent information agents will be at the helm of circumnavigating this digital globe in order to feed back essential information to individuals and computer systems alike.

Today there are perhaps just a few obvious applications of such agents such as the delivery of news, booking of holidays and business trips, and scheduling meetings. Each of these require agents to be fed certain amounts of knowledge but also literally to go out onto the networks and hunt down other relevant information. In doing so the agents learn and build a body of knowledge along the way, which is analogous to human development.

The importance of intelligent agents was recently summarised by Hyacinth Nwana, of BT Laboratories:

'... (Intelligent) agents are here to stay, not least because of their diversity, their wide range of applicability and the broad spectrum of companies investing in them. As we move further and further into the information age, any information-based organisation which does not invest in agent technology may be committing commercial hara-kiri!' (Ref 17).

This is further emphasised by initiation of a first international conference on autonomous agents, due to take place in California in February 1997, which includes co-sponsorship from British Telecom, Microsoft and Mitsubishi among others (Ref 18). This is just one of some 30 conferences which have tracks on, or relate to, intelligent agents taking place between June 1996 and April 1997. The Distributed Artificial Intelligence (DAI) Unit in the Department of Electronic Engineering at Queen Mary and Westfield College has developed and applied DAI and agent based techniques to real world problems in a wide range of commercial and industrial domains. Applications which have been addressed include: electricity, transportation management, electricity distribution management, particle accelerator control, patient care, concurrent engineering, digital libraries and business process management.

It is possible that agent intermediaries will replace their human counterparts. But what is far more likely is that human intermediaries will have to work in close cooperation with their agents, such that there is an evolution in the tasks performed by both. In the short-term intelligent agents will handle the more mundane tasks of information retrieval and searching whereas humans will undertake the more difficult problem-solving tasks. Eventually this will lead to niche specialisations by humans with the agents undertaking ever more everyday tasks. Further research clearly is important to understand just how this evolution of roles may occur.

Today intelligent agents offer a relatively simple form of functionality, in the main via user input into a form or table which is then unleashed to search. Some of these need to remain running directly from a user's desktop, such as AutoNomy's Agentware, whilst others work in the background simply watching passages of data, such as the Topic Information Agents from Verity Inc. (Refs 19, 20). However, there will be an increasing demand for network-based agents which reside remotely and only report back to users either when requested to do so or when certain relevant information has been gathered. According to Hermans, 'agent-empowered software that is as effective as a research librarian for content search will be available in 1998, and may be expected to be used by a significant number of users near the year 2000.'

Intelligent information agents are the way forward — in fact, the key to the future Information Society.

A.J. Garcia-Sierra
BT Postgraduate Researcher
BT Electronic Commerce Innovation Centre
Cardiff University of Wales
PO Box 907
Cardiff CF1 3YP
UK
Tel: +44 (0)1222 874271
Fax: +44 (0)1222 874301
E-mail: garcia-sierra@cardiff.ac.uk
http://www.cf.ac.uk/uwcc/masts/ecic/

References

[1] Bangemann, M. *et al.* (1994) *Europe and the Global Information Society: Recommendations to the European Council*, European Union, Brussels.

[2] Cochrane, P. and R. Smith (1994) 21st century information systems, *British Computer Society Expert Systems 1994 Conference*, Cambridge, pp. 3–17.

[3] Department of Trade & Industry (1995) *The Information Society Initiative*, http://www.isi.gov.uk/introisi/introisi.html.

[4] House of Commons (1995) House of Commons Debate: the Select Committee on Trade Industry Report on Broadband Networks (the Information Superhighway), London.

[5] Barnes, J. *et al.* (1994) *Internet Futures*, BT Laboratories.

[6] Patrick, J. (1996) Renaissance through the Internet, *6th EC World Congress of EC Users & Expo 1996*, Vancouver.

[7] Wallis, J. and P. Burden (1995) *Towards a classification-based approach to resource discovery on the Web*, University of Wolverhampton, http://www.scit.wlv.ac.uk/~cm5234/project/agent_info/ dataman.html

[8] Maudlin (1995) Measuring the Web with Lycos, *Third International World-Wide Web Conference*, 11 April, http://lycos.cs.cmu.edu/lycos-websize.html

[9] Wayner, P. (1995) *Agents Unleashed: A Public Domain Look at Agents Technology*, Academic Press, Inc., Chestnut Hill.

[10] Cochrane, P. and R. Smith (1994) 21st century information systems, *British Computer Society Expert Systems 1994 Conference*, Cambridge, pp. 3-17.

[11] Durfee, E. *et al.* (1995) *Intelligent Agent Infrastructures for Supporting Collaborative Work*, http://ksi.cpsc.ucalgary.ca/courses/547-95/bentley/AGENTS.html

[12] Maes, P. (1990) Situated agents can have goals, in P. Maes (Ed.) *Designing Autonomous Agents: Theory and Practice from Biology to Engineering and Back*, The MIT Press, London.

[13] Stephens, K.R. (1995) Behaviour analysis and intelligent agent theory, *CIKM-95 Workshop on Intelligent Information Agents*.

[14] BT Laboratories (1996) *BT Technology Journal*, to be published October 1996.

[15] Massachusetts Institute of Technology Media Laboratory, http://www.mit.media.edu

[16] Negroponte, N. (1995) *Being Digital*, Vintage Books, New York.

[17] Hermans, B. (1996) *Intelligent software agents on the Internet: an inventory of currently offered functionality in the information society and prediction of (near-) future developments*, Tilburg University Masters Thesis, http://www.hermans.org/agents.

[18] Nwana, H. (1996) Software agents: an overview, *Intelligent Systems Research AA&T*, BT Laboratories, Ipswich. http://www.cs.umbc.edu/agents/papers/ao.ps.

[19] The First International Conference on Autonomous Agents, Marina del Rey, California, 5–8 February 1997. http://www.isi.edu/isd/AA97/info.html.

[20] AutoNomy home page: http://www.agentware.com.

[21] Verity, Inc. home page: http://www.verity.com.